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Relative strength of the 2010, 2011 and 2012 year classes, from nearshore surveys of demersal age 0 and 1 Atlantic cod in Newman Sound, Bonavista Bay

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Foreword

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ABSTRACT

We surveyed demersal age 0 and 1 year old Atlantic cod (*Gadus morhua*) in the nearshore (<10 m deep) during the past 17 seasons using a seine net, to conduct a qualitative assessment of the strength of these year-classes. Our assessment was based on comparisons with abundance of Atlantic cod sampled at 6-13 sites, every two weeks from July until November, from 1995-2012 in Newman Sound, Bonavista Bay. Analysis of annual length frequency and abundance data indicated that age 0 Atlantic cod settled in the nearshore in several distinct recruitment pulses, the first pulse arriving in early July (2012) or early August (2010 and 2011). Second and subsequent pulses followed the first by as much as a month and a half later. Strong pulse structure throughout the sampling period typically has resulted in the production of a strong cohort as measured independently during other surveys. Interestingly, the 2010 cohort appeared to be weak as age 0 individuals, but apparently high survival resulted in higher than expected numbers of one year olds sampled in 2011. The age 0 abundance in Newman Sound in 2011 and 2012 suggests that these two cohorts will also be moderate to strong, relative to other cohorts in the 17-year long time series. The 2012 cohort was second strongest in the 17 year time series in terms of mean abundance per set, timing of settlement, and strength of its recruitment pulse structure. This pre-recruit survey data indicates that stronger than average year classes have been produced during each of the past 3 years, compared to our 17 years of monitoring data.

Importance relative des classes d'âge de 2010, de 2011 et de 2012 d'après les relevés côtiers de la morue franche démersale de 0 et 1 an dans le bras Newman, baie de Bonavista

RÉSUMÉ

Nous avons effectué des relevés à la senne de la morue franche (*Gadus morhua*) démersale de 0 et 1 an dans les eaux côtières (< 10 m de profondeur) au cours des 17 dernières saisons afin de procéder à une évaluation qualitative de l'importance de ces classes d'âge. Notre évaluation est fondée sur des comparaisons de l'abondance de la morue franche dont un échantillon a été prélevé dans 6 à 13 sites toutes les deux semaines, de juillet à novembre, de 1995 à 2012, dans le bras Newman, baie de Bonavista. L'analyse de la fréquence de longueur annuelle et des données sur l'abondance indique que la morue franche d'âge 0 s'est établie dans la zone côtière en plusieurs vagues de recrutement distinctes, la première au début de juillet (2012) ou d'août (2010 et 2011). La deuxième vague et les vagues de recrutement subséquentes ont suivi la première de plus d'un mois et demi. En général, une structure solide des vagues de recrutement pendant la période d'échantillonnage a entraîné la production d'une cohorte abondante selon les mesures prises indépendamment dans d'autres relevés. Il est intéressant de noter que la cohorte de 2010 semblait peu abondante à l'âge 0, mais en raison du taux de survie élevé, il y aurait eu un plus grand nombre de morues âgées de 1 an que prévu dans les échantillons prélevés en 2011. L'abondance de morues de 0 an dans le bras Newman en 2011 et en 2012 laisse entendre que ces deux cohortes seront aussi relativement abondantes par rapport aux autres cohortes de la série chronologique de 17 ans. La cohorte de 2012 était la deuxième plus abondante des 17 années de la série chronologique pour ce qui est de l'abondance moyenne par ensemble, de la date d'établissement et de la force de la structure de la vague de recrutement. Les données d'enquête de prérecrues indiquent que des classes d'âge plus abondantes que la moyenne ont été produites pendant chacune des trois dernières années par rapport aux 17 années de données de surveillance.

INTRODUCTION

Age 0 and 1 year-old Atlantic cod in the Northwest Atlantic Fisheries Organization (NAFO) Subdivisions 3K and 3L (Northeast Newfoundland Shelf) are distributed predominantly in inshore waters (Dalley and Anderson 1997). Within these inshore waters during autumn, age 0 cod are most common in depths less than 10 m (Methven and Schneider 1998). The Fleming surveys (1959-64, Lear et al. 1980; 1992-2001, e.g., Methven et al. 1998) have historically sampled nearshore abundances of age 0-2 Atlantic cod, with the objective of assessing relative year-class strength. Throughout these surveys, the relative strength of adjacent cohorts has been carried through to subsequent age groups within the cohort over time through the first years of life (Schneider et al. 1997).

In autumn 1995, an investigation of the abundance of age 0 cod and their association with nearshore habitat types was initiated in Newman Sound, Bonavista Bay (Gotceitas et al. 1996). The 1995 study was followed by similar efforts in the years 1996-2006 (Gregory et al. 1997, 1998, 1999, 2000, 2002, 2004, 2006). These studies have collectively shown that the nearshore of Newman Sound is a nursery area for demersal fishes, including age 0 Atlantic cod. In our study, we have continued to track the strength of temporally adjacent cohorts in Newman Sound, through the first years of life.

In this study, we qualitatively assessed the relative strength of the 2010, 2011 and 2012 year-classes based on abundance of demersal age 0 and age 1 Atlantic cod in Newman Sound, Bonavista Bay in summer and autumn of those years. We compared abundances of age 0 and age 1 Atlantic cod in 2010, 2011 and 2012 to those in previous years (1995-2009). We then linked these inter-annual abundance trends to those demonstrated in broader based inshore surveys elsewhere along the northeast Newfoundland coast. We have previously shown that inter-annual trends between the Newman Sound data and the larger geographic scale Fleming survey data are consistent (Gregory et al. 2002, 2004, 2006; Methven et al. 1998). We also suggest that in years of relatively higher recruitment, settlement occurs in more than one recruitment pulse (Methven and Bajdik 1994, Grant and Brown 1998, Gregory et al. 2006) several weeks apart. Five of the eight year classes the past decade are weaker than those of the mid-1990s, but the most recent six years (since 2006) contrasts with these findings, representing several of the strongest cohorts we have observed in Newman Sound during the 17 year period, ending in 2012.

METHODS

Newman Sound seine sites (Fig. 1) – described in Gregory et al. (1997) – were selected on the basis of sampling logistics. We have used seasonal catch data from all 12 of our primary study sites, sampled every two weeks from July to November. Fish samples were collected using a 25 m beach seine - wings and belly 19 mm stretch mesh, codend 9 mm stretch mesh bag; 24.4 m headrope, 26.2 m footrope. Aluminum poles – 75 cm long and 25 mm diameter – on each wing served to maintain the spread between the headrope and footrope. The net was deployed from a 6 m boat at a distance of 55 m from the shore, and then retrieved by two individuals standing 16 m apart on the shore. The seine was pulled along the bottom and sampled the lowest 2 m of the water column. Deployed in the manner described, the net samples approximately 880 m^2 of the bottom.

All fish collected were identified and counted. Juvenile cod were assigned to tentative age groups based on previously established age-length relationships in Newfoundland waters in late autumn (age 0: $\leq$10 cm SL [standard length], age 1: 10 to 20 cm SL, and age 2: 20 to 30 cm SL - Dalley and Anderson 1997) and confirmed for age 0 and age 1 fish by examination

of otolith microstructure in 1996 and 1997. We then refined these estimates by examination of length frequency trajectories through time.

RESULTS AND DISCUSSION

The period 2010-12 has produced above average strength cohorts among the 17 year Newman Sound time series. The 1999 year-class remains the strongest cohort sampled since the implementation of the 1992 moratorium, and the 2006 cohort remains the lowest. During the past decade, the 2007, 2011 and 2012 year classes were relatively strong compared to adjacent cohorts, both as age 0 and as age 1 individuals (Fig. 2), consistent with moderate to high survival rates between years within individual cohorts in the nearshore.

In general, age 0 cod abundance has been a poor predictor of age 1 abundance within single cohorts of the Newman Sound dataset (Fig. 3). However, Newman Sound age 1 abundance and age 3 abundance from Inshore SPA (Sequential Population Analysis) have been positively and highly correlated (r^2 =0.803; p=0.0026) for 1995 to 2003 cohorts (DFO 2006). Although mortality rates between age 0 and 1 have proven difficult to predict, an annual settlement pattern represented by early settlement followed by a complex pulse structure has appeared consistently favourable to the production of a strong year class.

Age 0 Atlantic cod recruit (=settle) into nearshore habitats in several settlement pulses each year caused by unique combinations of offshore and onshore wind events each year (Ings et al. 2008). The implications of multiple recruitment pulses on the year-class strength of Atlantic cod and other gadid species was explored by Ings et al. (2008). Our data from 2010-12 (Figs. 4-6) suggest that a complex and temporally extended pulse structure observed during 2011-12 (e.g., two or more strong modes; Figs. 4 and 5) may signal relatively good recruitment years, compared to years with a simple or weak pulse structure (e.g., only one mode or multiple weak modes). The 2011 and 2012 year-classes showed evidence of three to four strong recruitment pulses about one month apart, a positive indication of relatively strong cohorts during our 17 year series. During weak recruitment years (e.g., 1996, 2001, 2003-04; Gregory et al. 2006), in which settlement to the nearshore is often late (i.e., late-August and even early September) accompanied by few strong pulses, a strong cohort is not expected.

A similar pulse structure is also generally observed over spatial scales covering multiple embayment's along the northeast Newfoundland coast, and do not appear unique to the vicinity of individual nursery areas such as Newman Sound. Similar recruitment patterns occur annually at widely separated sites along the northeast Newfoundland coast (Methven and Bajdik 1994, Grant and Brown 1998) suggesting that these observations reflect broader geographic phenomena. We investigated this pattern further in 2007 by conducting a protracted juvenile fish beach seining program in Smith Sound, Trinity Bay as well as our annual Newman Sound effort (Gregory and Morris, unpublished data). The seasonal size pattern of age 0 juveniles in Smith Sound were very similar to those in Newman Sound, suggesting that similar settlement dynamics were at play over wider geographic areas and is not restricted localized to a single embayment. From genetic evidence, we also know that different stock components contributed differentially to each of these pulses in 1999 (Beacham et al. 2000). However, it remains to be determined if individual stock components contribute only to a single pulse. Size-selective mortality factors should effect differential survival between individuals from different recruitment pulses (Sogard 1997). Our evidence from the Newman Sound cod nursery area suggests that age 0 mortality rates are highly variability - between 0.5-11 % d^{-1}.

Based on the results of this study, we make the following conclusions:

- the 2010 cohort will likely be strong compared to others in the previous 7 years, with the exception of 2007 year class.;
- the 2011 cohort is of moderate strength within the past decade; and
- the 2012 year class strength will be relatively high comparable to the 1999 cohort.

ACKNOWLEDGEMENTS

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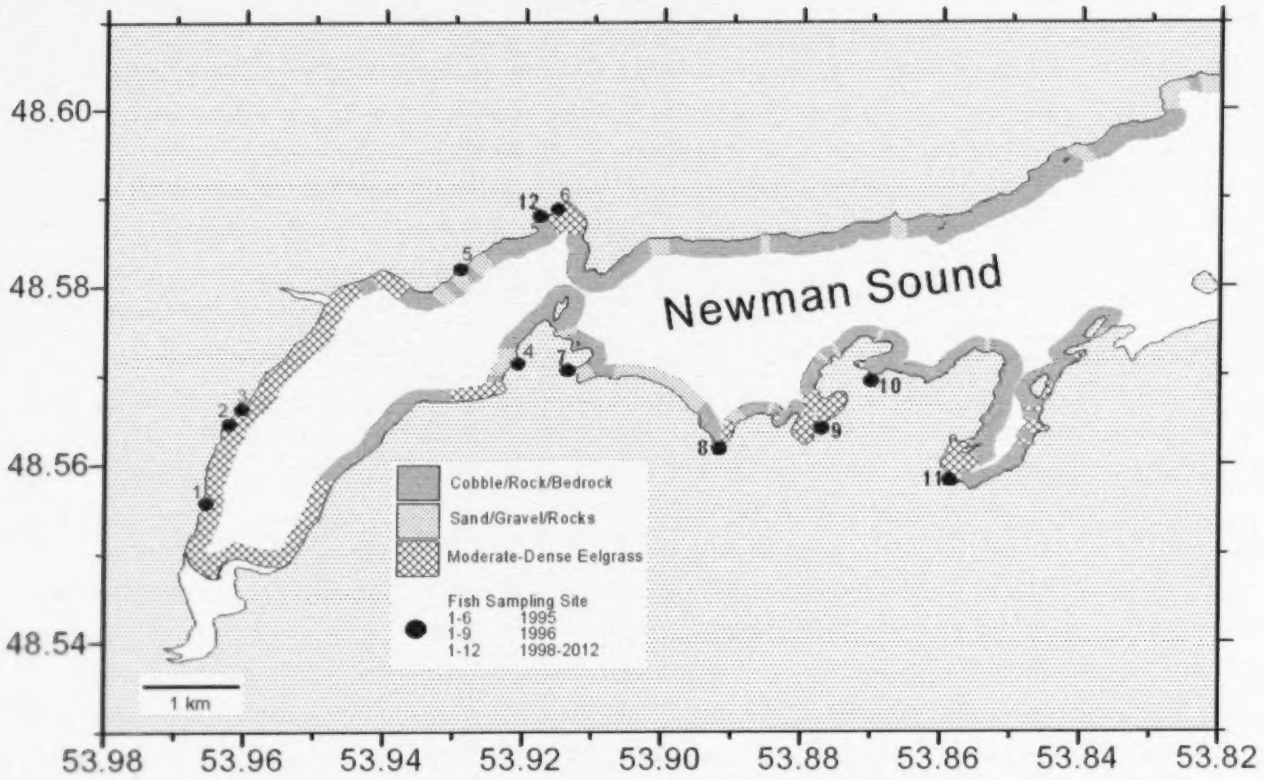

Figure 1. Location of sampling sites and nearshore habitat in Newman Sound, Bonavista Bay, 1995-2012.

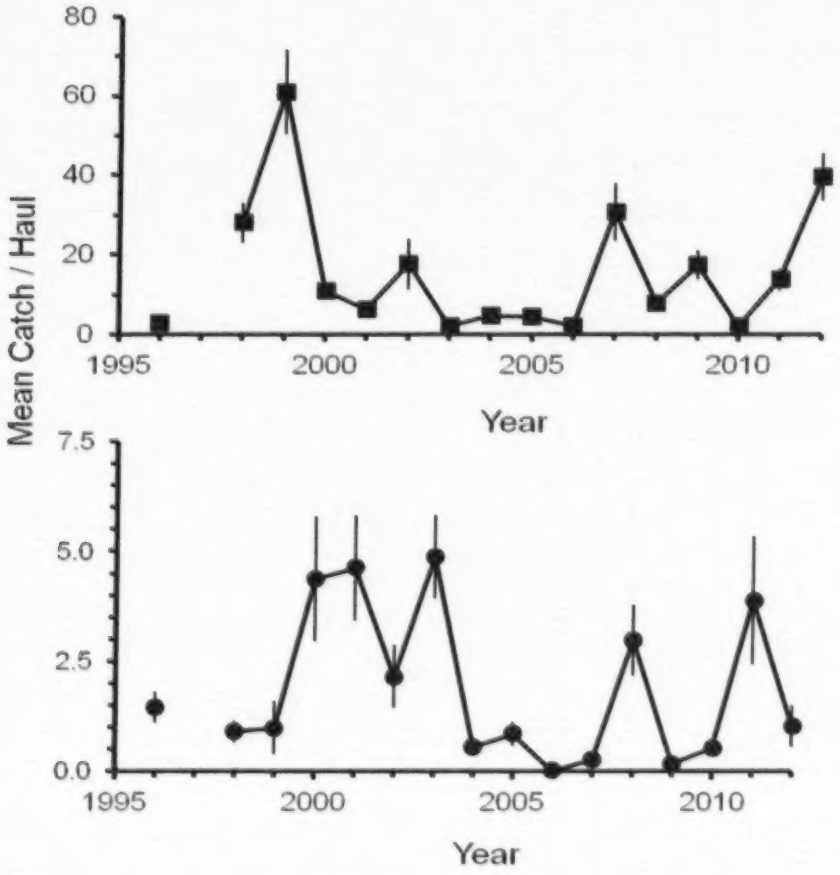

Figure 2. Mean age 0 (top panel) and age 1 year old (bottom panel) Atlantic cod caught annually by beach seine in Newman Sound Bonavista Bay, 1995-2012 (bars are +/-1 SE; n=105-132 seine hauls/year).

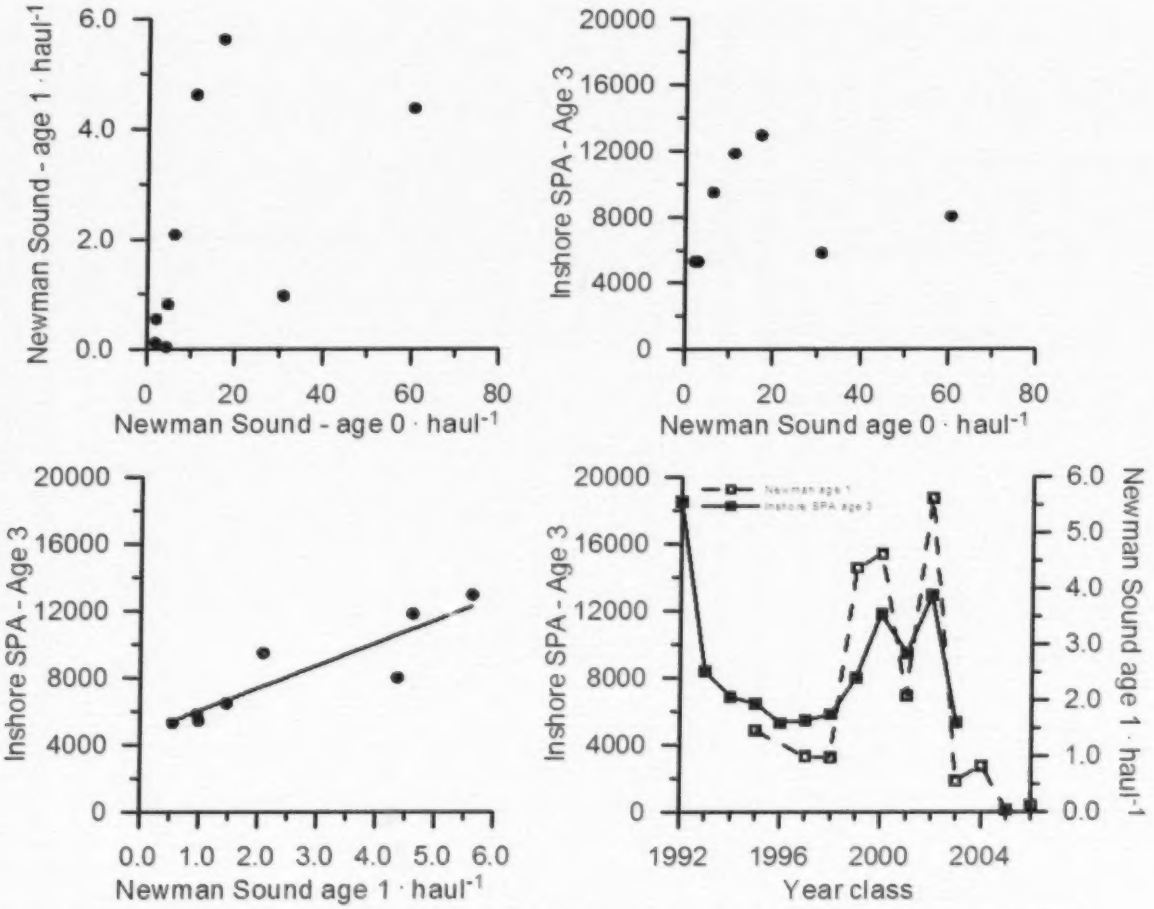
Newman Sound - age 1 · haul-1
Newman Sound - age 0 · haul-1
Inshore SPA - Age 3
Newman Sound age 0 · haul-1
Inshore SPA - Age 3
Newman Sound age 1 · haul-1
Inshore SPA - Age 3
Year class
Newman Sound age 1 · haul-1

Figure 3. Age 0 and 1 year old Atlantic cod caught by beach seine in Newman Sound Bonavista Bay, 1996-2007, and numerically compared to the inshore SPA for age 3 (DFO 2006).

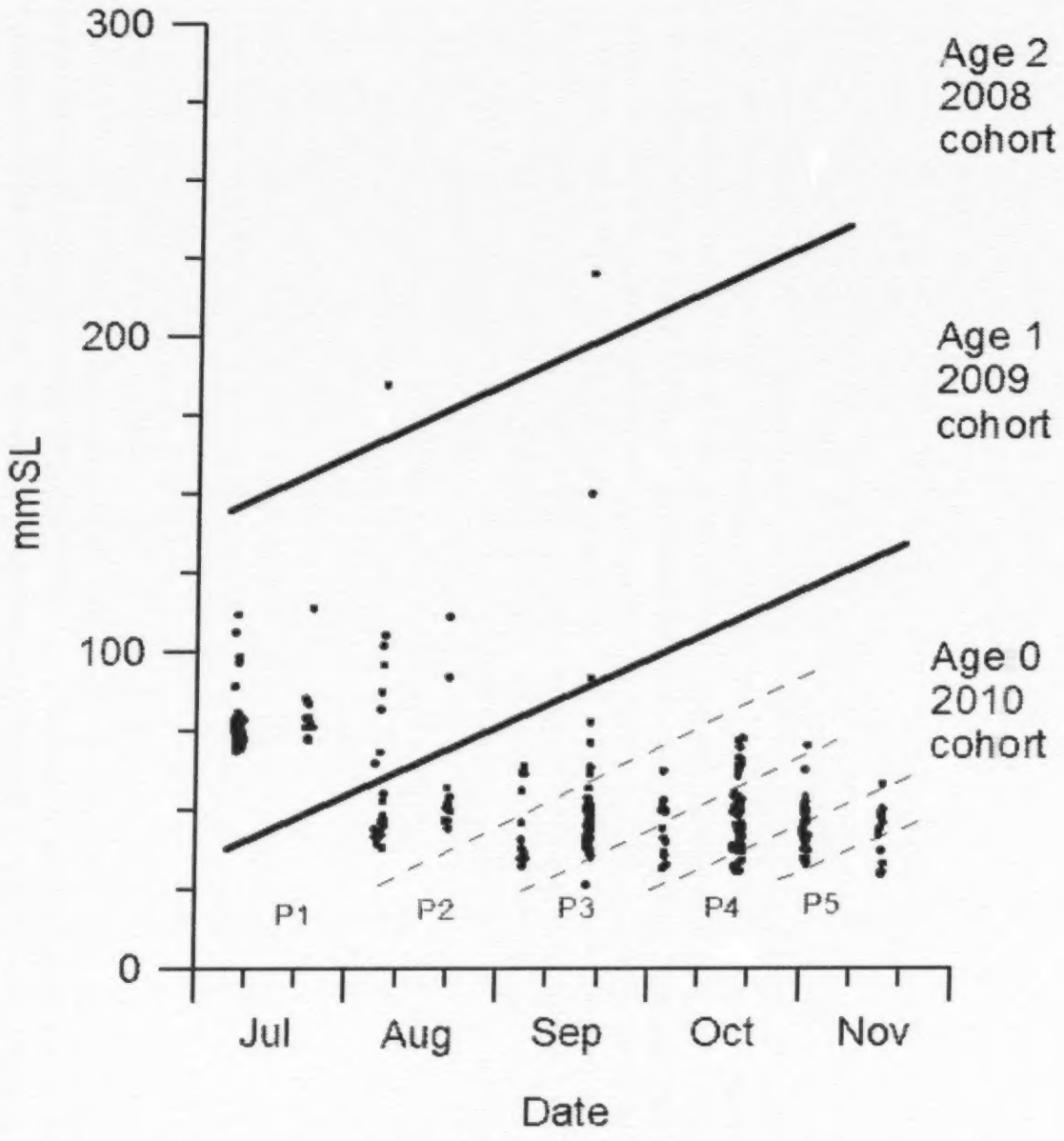

Figure 4. Sizes of Atlantic cod captured by beach seine in Newman Sound Bonavista Bay, July - November, 2010 and their potential age and recruitment pulse structure (P = pulse).

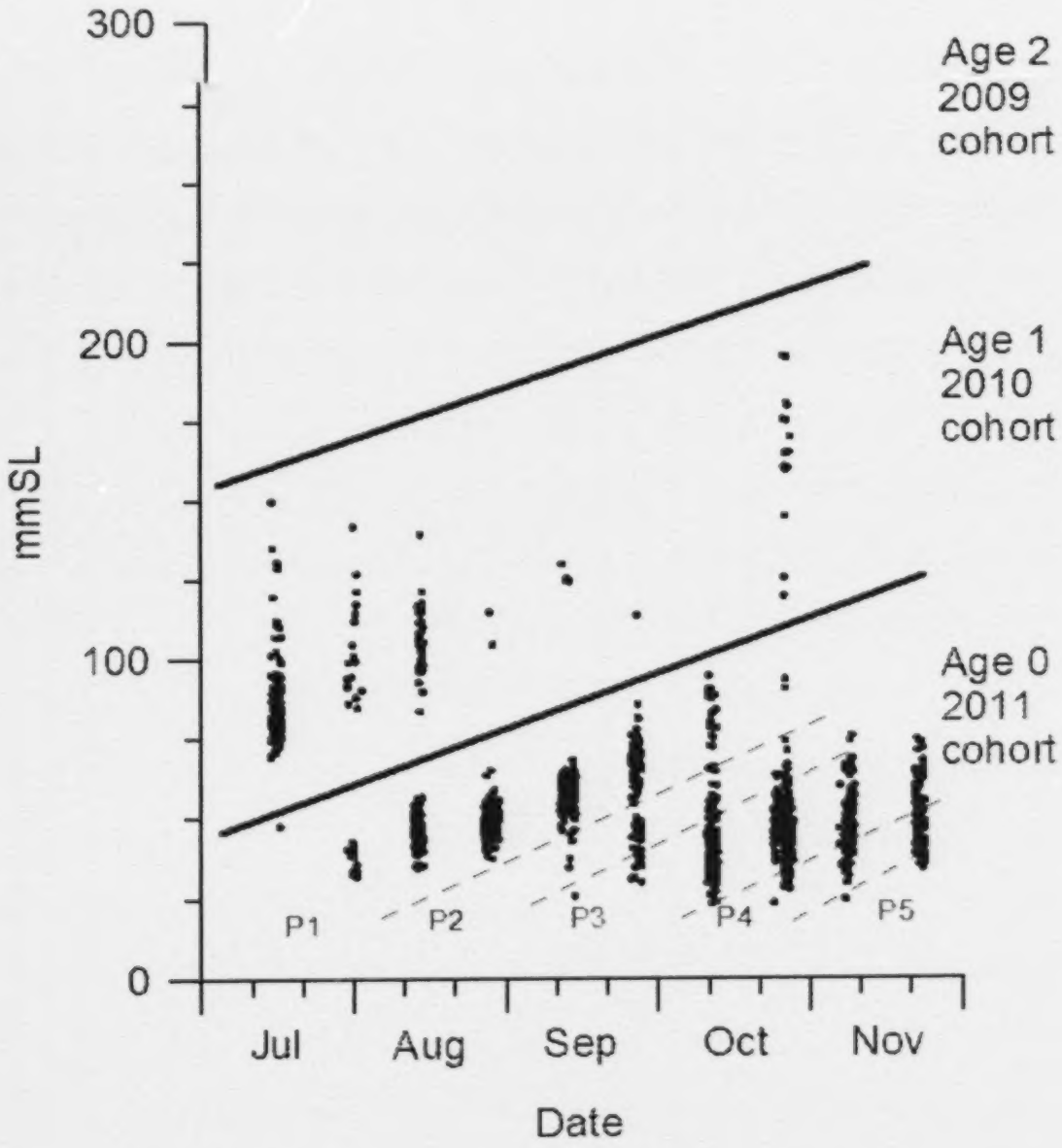

Figure 5. Sizes of Atlantic cod captured by beach seine in Newman Sound, Bonavista Bay, July - November, 2011 and their potential age and recruitment pulse structure (P = pulse).

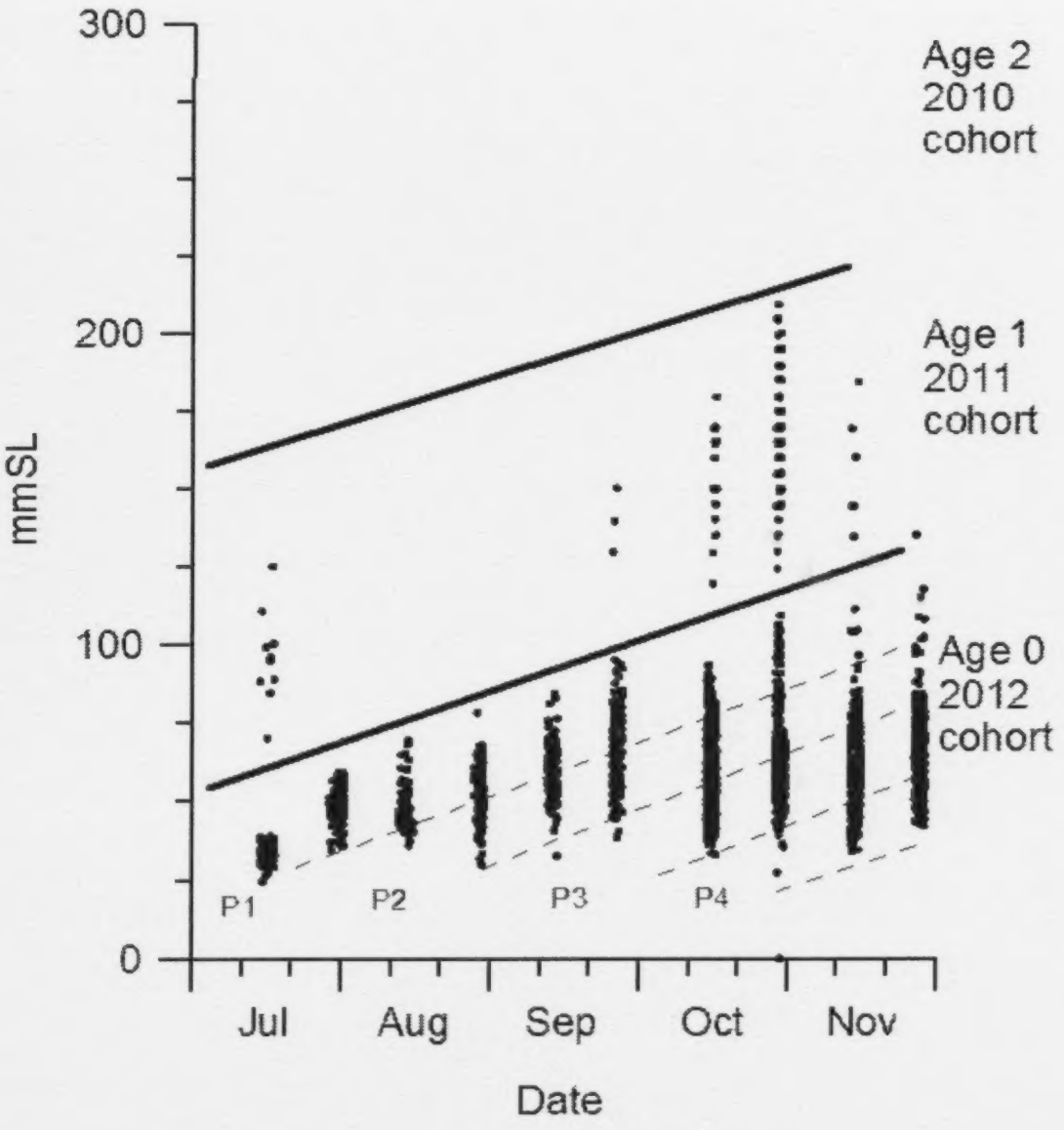

Figure 6. Sizes of Atlantic cod captured by beach seine in Newman Sound, Bonavista Bay, July - November, 2012 and their potential age and recruitment pulse structure (P = pulse).